Guglielmo Marconi and the History of Radio – Part I

by G. A. Isted, M.I.E.E.
Personal Technical Assistant to G. Marconi, 1926 – 1936

G. A. Isted was born in 1903 and joined the Marconi Company at Chelmsford in 1923. In 1926 he was transferred to G. Marconi's private laboratory in London. In 1929 he was sent to Italy as Marconi's personal technical assistant and participated in Marconi's microwave experiments. When hostilities broke out between Italy and Abyssinia in 1935, he was recalled to England where he joined the staff of T. L. Eckersley who was studying radio wave propagation, mostly at Gt. Baddow. During World War II, he was in charge of the RAF section of the Inter-Services Ionospheric Bureau based at Great Baddow. Subsequent to Eckersley's retirement, he became Chief of the Marconi Radio-wave Propagation Group. He was largely responsible for the success of the nationwide coverage of the Independent Television Authority Band III television service. He retired in 1969 after 46 years with the Marconi Company.

A study of the developments leading towards a practical system of wireless telegraph communication clearly shows that there were five independent but complementary streams which scientists and engineers followed. These streams converged and eventually coalesced between the years 1890 and 1896.

The first and most important stream was followed by the scientists who indicated the presence and nature of the medium in which wireless waves could be propagated. The second stream was followed by the scientists and engineers who invented the means to generate electromagnetic waves. The third stream, also followed by scientists and engineers, yielded the means to detect electromagnetic waves after they had been transmitted. It is worthy of note that, at the time they were invented, these last two inventions were completely divorced from wireless telegraphy and from each other. The fourth stream was reserved for the engineers who already had their eyes on the practical application of communication by electricity without interconnecting wires and who carried out 'feeler' experiments, but who were hampered by the lack of experience and facilities. The final stream was followed by a series of unrelated events each having a close association with the new art.

The coalescence of these five streams into a viable system of communication was destined to revolutionize the lives of mankind.

Early Experiments

From the middle of the 19th century onwards the minds of telegraphic engineers were occupied with the idea that communication of the future would be by electrical installations that were not connected by wires, and many different experiments were carried out towards that end. Heinrich Hertz had not at this point produced his brilliant work showing how to generate and detect 'Maxwellian radiations'.

Most of the early wireless experiments were carried out by means of the induction system involving long wire circuits or conduction through the earth, but not by Hertzian waves. From the historical point of view, the Hertzian method of communication was somewhat obscured by these early experiments.

The first recorded attempt to communicate without interconnecting wires was made by Loomis in the United States. In 1858, he arranged for two separate vertical wires, 600 feet long, to be held aloft by kites on two mountain peaks 18 miles apart. Each wire was connected through a galvanometer to a coil of wire buried in wet ground. It was observed that, when one wire was connected or disconnected, the galvanometer needle in the other wire was deflected. It is claimed that Loomis did transmit intelligible messages over a distance of 14 miles in 1866. He patented his system of 'wireless' communication in 1872 but failed to get support to develop it further. The experiments are described in Loomis' notebook dated 1864, now lodged with the United States Library of Congress.

William Preece, Chief Engineer of the British Post Office, carried out tests of communication without connecting wires when, in 1882, the submarine cable between the Isle of Wight and the mainland broke down. Preece immersed two copper plates in the water on the mainland side of the Solent, separated by many miles, and connected them by an insulated wire. Correspondingly, he placed two more copper plates in the water along the Island side of the Solent, connecting them also by a wire. He then interrupted the mainland connecting wire at Southampton and the Island wire at Newport. He claimed that, when he inserted an instrument to make and break the current very rapidly with a buzzing sound and by using a Morse key and 30 Leclanché cells at Southampton, it was possible to read messages with a telephone at Newport, and vice versa.

In the following years, Preece carried out similar experiments at many places in the British Isles, including the first series of tests between Lavernock and the island of Flat Holme in the Bristol Channel, a distance of 3.3 miles.

Probably the earliest successful attempt at communication by means of a system in which a single earth connection was used at each station was that carried out by Professor Dolbear who, in 1882, applied for an American patent for his system. In his final arrangement he connected one terminal of the induction coil transmitter to an earth plate; the other terminal he connected to a short vertical wire at the end of which was a large capacity plate. The receiver was an ordinary telephone, one side of which was connected to an earth plate, the other side to a short vertical wire with a large capacity plate at its end. Communication distances of up to half a mile were attained. In the apparatus described no mention is made of a spark-gap associated with the transmitter, nor of any detecting device apart from a telephone. It seems certain that electromagnetic radiation of the type that was soon to be demonstrated by Hertz was not involved, but the induction/earth current method so popular with experimenters then, combined with electrostatic excitation

It was in 1887 that the work of Hertz was to provide the breakthrough which paved the way for electromagnetic wireless communication. When he decided to investigate the problem of demonstrating experimentally that the properties of the electromagnetic field were as Maxwell described, he had the advantage of having the latest resources and knowledge at his disposal. He was well aware of the oscillatory nature of the disruptive discharge from a Leyden Jar and, with a Ruhmkorff induction coil providing the energy, he completed his transmitter by placing a 'Hertzian radiator' – consisting of two linear conductors – across the terminals of the spark-gap.

The receiver consisted very simply of a single loop of stiff wire broken by a small adjustable spark-gap. This loop was adjusted, or tuned, for maximum sparking across the small gap when the transmitter was functioning. The received energy was so feeble, however, that it had to be observed in a darkened environment.

By his experiments, Hertz was able to confirm the theories of Maxwell, for he was able to generate, detect and measure electromagnetic waves and their associated phenomena for the first time. He found a close relationship between these invisible waves and light, for he was able to further demonstrate that electromagnetic waves could be reflected, refracted and polarized just as light waves were.

Hertz's results caused a revolution in scientific thinking about electricity. Professor Oliver Heaviside is said to have exclaimed when learning of Hertz's results:

'Three years ago electromagnetic waves were nowhere; shortly afterwards they were everywhere.'

There is little doubt that man-made 'wireless' transmission was born in Hertz's laboratory. It seems strange that it did not then occur to Hertz to put his ideas and studies to practical use. It was for others to reap the benefit of such a promising start; but, nevertheless, it was to be several years before that happened.

Hertz died in 1894 at the early age of 37 and, five months later, Sir Oliver Lodge delivered a commemorative lecture on 'The Work of Hertz' at the Royal Institution, London. This lecture was remarkable in many ways. For the first time, it gave many people the opportunity to witness striking experiments performed with Hertzian or Maxwellian waves. These included experiments on their reflection, refraction and polarization, and their ability to pass through stone walls from room to room. Yet, although replete with interest, the lecture contained not even a hint of a possible application of electromagnetic waves to communication by telegraphy. The lecture was, in fact, a scientific demonstration of the undulatory character of the electromagnetic radiation from an oscillator and of the electromagnetic nature of ordinary light.

In a repeat lecture later in the same year to the British Association at Oxford, Lodge again demonstrated the fascinating properties of Hertzian waves. For one experiment, he placed in the Clarendon Laboratory a Hertz radiator to which he connected an ordinary induction coil controlled by a Morse key. In the Museum Lecture Room he then installed his receiver consisting of a replica of the Hertz radiator. But, in this case, it was connected to a voltaic battery and a sensitive 'coherer' detector fitted with an ingenious device for automatically tapping the detector to restore it to its original state after it had operated; at the same time, the tapper was arranged to operate a recorder. By this means he demonstrated that, when the transmitter Morse key in the Clarendon Laboratory was depressed, it caused a mark to be made on the receiver Morse recorder in the Museum Lecture Room.

This is the earliest recorded instance of the transmission and reception of a signal by Hertzian waves and it is clearly of great historical importance. Nevertheless, as both Professor J. A. Fleming and Dr. J. Erskine-Murray go to some pains to point out in their separate accounts of the lectures, on each occasion the possibilities of communication by telegraphy were not envisaged at the time by the lecturer. The physicist, Lord Rayleigh, having witnessed the demonstrations, commented in the discussion: 'If you follow that up, there is a life's work in it'. Lodge admitted later that Rayleigh was quite right, but he did not follow it up effectively as he was 'too busy with teaching work to take up telegraphy or any other development'.

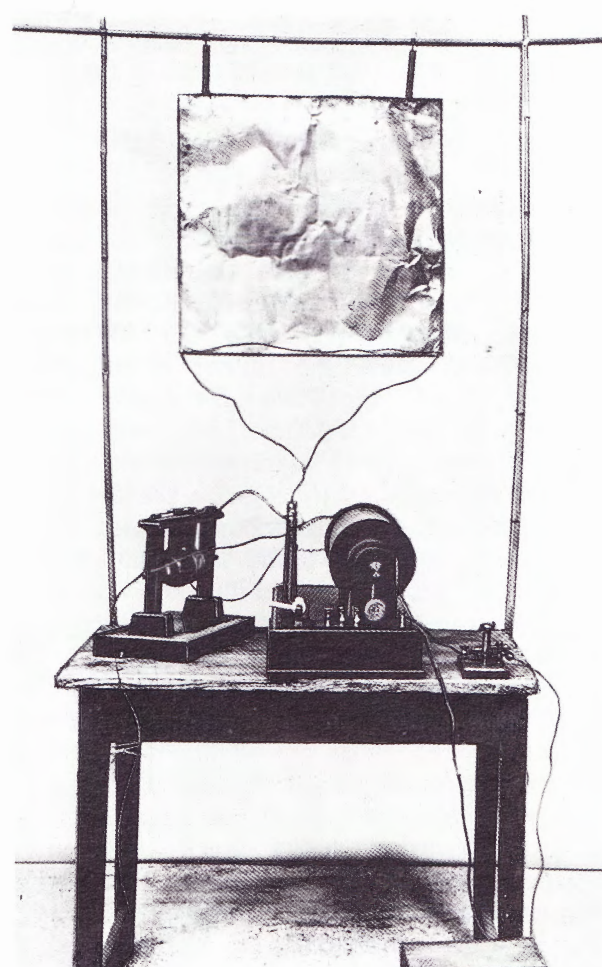
These lectures, bringing home so forcibly the power of an electric spark to affect instruments at a distant place, must have turned the thoughts of many inventive individuals to its utilization as a means of communicating from place to place without interconnecting wires.

1 *The Villa Grifone. Marconi is buried in the mausoleum shown in the foreground.*

Enter Guglielmo Marconi

One such person was a young Italian from Bologna, Marconi. He had read about Hertz's work, and indeed the work of many scientists and engineers, and, at the tender age of twenty, he set up a laboratory in the Villa Grifone where he lived (fig. 1), and set to work with the avowed intention of establishing telegraphic communication without interconnecting wires. He showed remarkable ability and scientific insight in being able to see the defects in the apparatus of much older workers and very quickly appreciated the requirements for a practical system of electromagnetic telegraphy. In the first year of his work he experimented and improved upon the coherer detector, the induction coil and parabolic directional aerials.

By 1895, Marconi had completed his experimental apparatus (fig. 2). By incorporating an automatic tapper with his coherer and by adopting a raised aerial arrangement, he achieved a great increase in the distances over which he could transmit. The aerial consisted of a short length of wire at the end of which a zinc plate was attached; an earthed lead completed his apparatus. It is said that he was able to transmit over a distance of 1.5 miles by the end of 1895.



2 *A replica of Marconi's transmitter which he used in experiments in Italy in 1894*

In that same year, Popov, of the Russian Navy Torpedo School at Kronstadt, had access to a good library with most of the foreign journals and books. These stimulated his interest in scientific research, particularly in the work of Hertz, whose experiments he was able to repeat. He was also greatly impressed on reading the lecture and description of experiments given by Oliver Lodge in 1894. He very quickly duplicated Lodge's receiving apparatus and installed it at a meteorological observatory. There he connected it to a lightning conductor and used it to record lightning occurring at a distance of up to 20 miles away.

Popov's receiving apparatus was described in the St. Petersburg Physical Society Journal in January 1896 simply as a lightning recorder. It is highly probable that neither Marconi nor Popov was aware of the near-parallel experiments being conducted independently by the other.

In 1895, Capt. H. B. Jackson of the Royal Navy succeeded in exchanging messages by Morse code between two warships using induction apparatus that he devised himself. This was good enough to be employed on some of H.M. ships but was ultimately replaced by Marconi's equipment. When Jackson and Marconi met they treated each other with friendship and respect.

Unrelated Events

An account of the development of wireless telegraphy would not be complete without reference to a series of seemingly unrelated events which occurred prior to the advent of wireless. All of these are worthy of mention because they provide the background against which the scientists and engineers achieved their great objective of wire-less communication.

The exact date at which the first observations of electrical phenomena were made, excepting the cave-man's observations of lightning, is really unknown, but they are usually attributed to Thales, a Greek, born at Miletus in the year 640 BC He is said to have noticed that amber, when rubbed, had the power of attracting light objects such as dry hair on a man's head. The Greek word for amber was 'elektron' from which springs our modern words electricity, electron, electro, etc.

No more appears to have been discovered about electricity until Gilbert found, in about 1600, that many other substances had the power to attract light objects when they were electrified by friction. Gilbert wrote a book on 'Magnetism and Attraction Between Bodies'. This was probably the first book dealing with electrical phenomena to have been written. Practically all our electrical knowledge has been acquired since that date.

The first glimmering of telegraphy by wires came in 1795 in a paper by Prof. Salva, an eminent Spanish physicist and inventor, entitled 'On the Application of Electricity to Telegraphy' and read before the Academy of Sciences, Barcelona. At one point Salva said:

'One could, for example, arrange at Mallorca an area of earth charged with electricity and at Alicante a similar space charged with the opposite electricity with a wire going to, and dipping into, the sea. On leading another wire from the seashore to the electrified spot at Mallorca the communication between the two charged surfaces would be complete, for the electric fluid would traverse the sea, which is an excellent conductor, and indicate by the spark the desired signal.'

Small wonder that Fahie[1] described this as a 'bizarre passage' and, although seriously meant 'cannot be regarded as more than a happy inspiration of genius'.

Although not of great importance in the present context, the year 1899 must be regarded as highly significant for the British public, for it saw the inauguration of the first public service of domestic electricity.

Wheatstone and Cook, two engineers who played a prominent part in telegraphic communication, patented the first wired telegraphic system in 1837. The advent of wired telegraphy was an event which was to open up amazing opportunities for communication throughout the world. The first wired telegraph route in Great Britain was laid between Euston and Camden Town on the London and Birmingham Railway.

From the earliest days of electric telegraphy, inventors had their attention directed to the problem of dispensing in part, or entirely, with continuous interconnecting wires. In 1836 Stenheil of Munich, acting on a suggestion by Gauss, carried out a test in wired telegraphy, between Nuremburg and Fürth, in an endeavour to use the railway lines in the place of properly insulated telegraph wires. The test proved a failure, but it led to a most important discovery. Rightly attributing failure of the experiment to leakage of electricity through the earth between the rails, the idea occurred to him that, because the earth appeared to be so good a conductor of electricity, it might possibly be employed in place of the return wire, which had been used up to that time. This experiment was tried and proved entirely successful, and it was undoubtedly an important contributions to successful telegraphic communication, not only for wired systems, but it probably also influenced the early adoption of the earth connection in the radiator for wireless.

The electric telegraph by metal conductors was destined to be the great competitor in the coming wireless telegraph war that was to be waged across the Atlantic Ocean.

The first transatlantic submarine cable, a milestone in telegraphic communication, was laid in 1858 after several mishaps during its installation. The project was sponsored by the Atlantic Telegraph Company, and was carried out by a joint Anglo-American team. The British supplied the cable and a ship, HMS 'Agamemnon', while the Americans supplied a second ship, the USS 'Niagara'. The 'Niagara' laid the first half of the cable starting at Valentia Island, County Kerry, and the second half was laid by the 'Agamemnon', finishing up at Trinity Bay, Newfoundland.

Unfortunately, the triumph of this first cable was short-lived. From the very first message, the cable proved to be unreliable and much repetition of messages was necessary. It was soon obvious that the insulation was impaired and, as time went on, signals became more and more unintelligible. After two months of operation the cable went completely dead and all further attempts to bring it to life were useless.

Subsequently, the cable ship 'Great Eastern', constructed specifically for submarine cable laying, succeeded in laying a series of cables across the Atlantic Ocean between the years 1865 and 1874. These cables were, in the main, successful and remained in service without competition until Marconi bridged the Atlantic by wireless telegraphy some thirty years later. Even then it was a decade or so before it became a serious challenge to cable telegraphy.

While the last transatlantic cable was being laid in 1874, a baby boy was born in Bologna, Italy, to Giuseppe and Annie Marconi. He was christened Guglielmo. The world was to hear much of this baby and of the Villa Grifone, his father's villa, in which he spent much of his young life. From there he was to throw down a challenge to the cable companies which, by achieving telegraphic communication across the Atlantic Ocean even before he was born, had gained such a start over him.

As if to pave the way for the adult Marconi, the requirements for a wireless telegraph communication system were defined by Sir William Crookes in 1892, well before anyone had given serious thought to telegraphy without wires. Crookes allowed his trained scientific imagination to concern itself with the recent discoveries, and these prompted him to write a monumental article entitled 'On Some Possibilities of Electricity', which was published in the 'Fortnightly Review'. In this article he endeavoured to forecast some of the applications of high-frequency electric currents and of Hertzian waves. In his look into the future he clearly discerned the coming wireless telegraphy based on the application of Hertz's work. While there is no description of invention in the article there is much prognostication.

Dealing with electromagnetic waves and their properties Crookes wrote:

'Here is unfolded to us a new and astonishing world, one which it is hard to conceive should contain no possibilities of transmitting and receiving intelligence.'

'Rays of light will not pierce through a wall, nor, as we know only too well, through a London fog. But the electrical vibrations of a yard or more in wavelength of which I have spoken will easily pierce such mediums which to them will be transparent. Here, then, is revealed the bewildering possibility of telegraphy without wires, posts, cables or any of our present costly appliances.'

'Granted a few reasonable postulates, the whole theory comes well within the realms of possible fulfilment. At the present time, experimentalists are able to generate electrical waves of any desired wavelength from a few feet upwards, and to keep up a succession of such waves radiating into space in all directions. It is possible, too, with some of these rays, to refract them through suitably shaped bodies acting as lenses, and so direct a sheaf of rays in any given direction. Also, an experimentalist at a distance can receive some, if not all, of these rays on a properly constituted instrument, and, by concerted signals, messages in the Morse Code can thus pass from one operator to another.'

'What therefore remains to be discovered is, first, simpler and more certain means of generating electrical rays of any desired wavelength, from the shortest, say, of a few feet in length, which will easily pass through buildings and fogs, to those long waves whose lengths are measured by tens of miles; second, more delicate receivers which will respond to wavelengths between certain defined limits and be silent to all others; third, means of darting the sheaf of rays in any desired direction, whether by lenses or reflectors, by the help of which the sensitiveness of the receiver (apparently the most difficult of the problems to be solved) would not need to be so delicate as when the rays to be picked up are simply radiating into space in all directions, and fading away according to the law of inverse squares.'

'I assume here that the progress of discovery would give instruments capable of adjustment by turning a screw or altering the length of a wire, so as to become receptive of wavelengths of any preconceived length.'

'This is no mere dream of a visionary philosopher. All the requisites needed to bring it within the grasp of daily life are well within the possibilities of discovery, and are so reasonable and so clearly in the path of researchers which are now being actively prosecuted in every capital of Europe that we may any day expect to hear that they have emerged from the realms of speculation into those of sober fact.'

Without question, Crookes must be given great credit for bringing together the five streams taken towards the development of wireless by laying sound foundations for the final solution. He had been able to visualize vividly what was needed to be done so that, even twenty years later, his 'wireless specification' was still valid. Without doubt, his paper was read and noted by Branly, Preece, Lodge, Popov, Jackson and Marconi. From that point the great race to produce a workable system of 'wireless telegraphy' then commenced.

Four years later, on February 2nd 1896, young Marconi, still only twenty-two years old, came to England with the wireless transmitting and receiving apparatus which he had constructed (fig. 3). With this system he was able to demonstrate convincingly to the British Post Office, the Royal Navy and the Army that he could communicate over distances of more than a mile.

The Teenage Marconi

Annie Jameson was an Irish girl who eloped to marry Giuseppe Marconi, an Italian widower much older than herself. From their marriage, performed privately at Boulogne-sur-Mer in France, a son, Alfonso, was born. Nine years later, in 1874, a second son – Guglielmo – was born.

Although Guglielmo was born in Giuseppe's town house in Bologna in central Italy, his young life was mostly spent at the Villa Grifone, the family estate house at Pontecchio near Bologna.

From all accounts Guglielmo did not lead a very happy childhood, mainly on account of his father's uncompromising disposition, for, in his dour and unyielding way, he ruled his household in the style of a martinet. Because of his mother's English connections, Guglielmo spent much of his time away from home on visits to England and to English-speaking families in Italy; consequently, his education was very much neglected.

3 *Marconi photographed shortly after his arrival in England from Italy in 1896 with his wireless apparatus*

By the time he was eventually sent to a school in Florence, he found it difficult to cope with the give-and-take in the classroom, or even to keep up academically with other children of his own age, many of whom made fun of his poor Italian accent. This unfortunate situation inevitably showed up in his character in that he was given to solitariness to a marked degree, so that even his parents failed to understand what was going on in his mind. Even at this early age he could be described as a 'loner'. He became self-sufficient and spent his spare time in reading scientific books and constructing ingenious mechanical and scientific devices without help or encouragement from his father.

It was a great disappointment to his father when Guglielmo failed to pass the entrance examination to the Italian Naval Academy. It was also a great disappointment to Guglielmo himself for he had developed a great liking for a seafaring career – a liking which almost amounted to an obsession which was to play a major part in his adult life. Guglielmo's father's anger knew no bounds, for he considered that the boy had dallied with his studies and had jeopardized his chances of a naval career.

Eventually, Guglielmo was entered into the Livorno Technical Institute and was happy at the prospect of receiving regular scientific training but, again, failure was to be his lot. His ambition at that time was to take up a recognized course leading to an electrical career, but he was even unable to pass his matriculation examination for entry to Bologna University.

Guglielmo's father became even more angry and even wrecked the devices that his son had constructed, and punished him by withholding the pocket money he was in the habit of receiving. Giuseppe was aghast that his son was nearly twenty years old and still, in his opinion, wasting his time and energy on aimless electrical experiments.

Guglielmo became more estranged from his father but, luckily, his mother – scarcely understanding what her son was doing – did all she could to encourage him to persevere in his efforts to make a career for himself in the electrical world. But, not properly understanding where the boy was heading, she went in desperation to Professor Righi, a professor at Bologna University and a near-neighbour of the Marconis, and begged him to allow Guglielmo to attend the laboratory classes he gave in the Department of Physics.

Righi was at that time intensely interested in the production and study of Hertzian waves and had himself contributed much original scientific work on the subject. The knowledge that he imparted to Guglielmo must have done more than anything else to mould the young man's activities which were to become a life-long obsession.

Under the guidance of Righi, young Guglielmo, throughout the winter of 1894 and the following spring, read in the University library all he could find about Hertz's work and the extension of it carried out by Lodge in his seminal lecture of 1894 in commemoration of Hertz's work. It is doubtful whether he had the basic knowledge to understand all that he read, but there and then he dedicated himself to produce apparatus by which intelligence could be conveyed between two places by an electrical system, without the aid of interconnecting wires.

In the seclusion of his attic laboratory at Villa Grifone, the seeds of an invention that would soon become the topic of conversation the world over were sown.

In this great task, Guglielmo had the benefit of the description of all the ingredients that Sir William Crookes named in his 'wireless specification' of 1892. He had also the scientific treatises of Maxwell and Faraday; the experimental work of Hertz and Lodge. He had seen the spark generator of Ruhmkorff, the Leyden Jar condenser, the coherer detector of Varley, Calzetti Onesti, Branly and Lodge, – all the components which must have been in daily use in Righi's laboratory at the University. He had also read, no doubt, of the loaded vertical aerial and earthed connection, patented by Dolbear in 1882.

What Guglielmo had to do was to improve upon those components and piece them together. His indomitable will, his intuitive mind and nimble fingers very quickly enabled him to construct his first workable system.

Very soon the distances over which he was able to transmit exceeded the space available in his attic laboratory. In order to test his system to the limit he took his apparatus out into the spacious grounds of the Villa Grifone. He then made the important discovery that, as he lengthened his vertical aerial wires, so the distances over which he could communicate increased notably. It is doubtful if at that stage he understood that, by lengthening his aerial, he was automatically increasing the length of his electromagnetic wave. It was soon to be found out that the longer the wavelength, the greater the ease with which it was possible to surmount obstacles such as hills.

Guglielmo was now ready to demonstrate his wireless communication system.

The Adult Marconi

By September of 1895, at the age of 21, Marconi had progressed to such an extent that he was able to inform the Italian Government, through friends in official quarters, that he had engineered an electrical system for wire-less communication, which had a range at that time of well over a mile. He offered this to the Italian Government for further development. It was a great disappointment when the offer was summarily refused without even further investigation.

Marconi's mother still had complete faith in her son, and what he had already achieved, although she understood little of the real implications. In February 1896 she made up her mind that England offered a better chance for her son's career. Mother and son subsequently set out on what turned out to be an historic journey to London.

With the help of relations and friends they eventually found accommodation in Hereford Road, Bayswater. They were particularly fortunate in having the cousin of Guglielmo, Henry Jameson-Davis, available to familiarize the young Marconi with his new surroundings.

It was from Hereford Road that Marconi and his mother set about writing the provisional specification for the patent covering his wireless communication system. This task was completed in a few months and, on June 2nd 1896, the documents were officially deposited in the London Patent Office. On July 2nd 1897, British Patent No. 12 039 was granted[(2)]. This was the first patent granted in the world in connection with wireless telegraph communication using electromagnetic waves, as demonstrated by Hertz.

Marconi thereby secured unto himself the credit, and indeed the honour, of being first in the field of true wireless telegraphic invention. Circuit diagrams of his apparatus are shown in our previous issue[(3)].

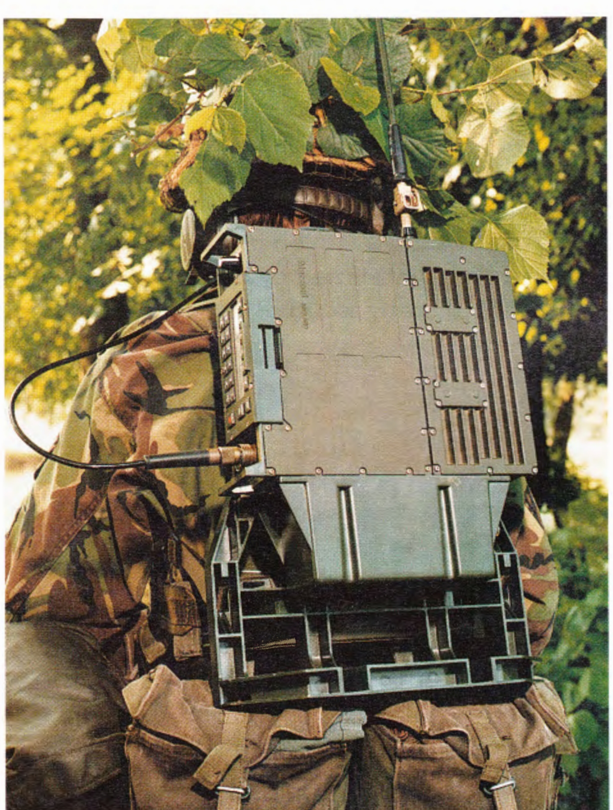
Marconi's next task was to gain access to influential people to whom he could demonstrate his communication system. By good fortune again, Henry Jameson-Davis moved in a circle of scientific friends, one of whom was Alan Campbell Swinton who was well-known for his own researches. Campbell Swinton undertook to effect an introduction to William Henry Preece, the Engineer-in-Chief of the British Post Office.

As described earlier, Preece himself was not uninformed on matters concerning communication, but, unlike Marconi, he had not appreciated the advantage to be gained by using Hertz's electromagnetic wave system. At the demonstration that took place following the introduction, Preece was very impressed and immediately decided that the Post Office must participate in Marconi's work.

In the days ahead, Preece became Marconi's staunch supporter. He offered Marconi the use of his own laboratory where he had been searching for the answer that Marconi seemed to have found; he even allowed Marconi to annex one of his most valuable assistants, George Stephen Kemp, who was to become Marconi's first and most loyal assistant.

The first demonstration took place between the Post Office in St. Martins-Le-Grand and the Savings Bank in Queen Victoria Street. It was completely successful and Preece urged Marconi to carry out further tests across Salisbury Plain. For these tests, a bungalow called 'Hillcrest', on the A30 road was chosen in which to install the fixed transmitting apparatus. The receiver was carried on a vehicle supplied by the Army. The modern equivalent, the 'Scimitar' military transceiver, is shown in fig. 4.

Marconi said that he used parabolic reflectors and resonators operating on a wavelength of 30 centimetres. Later in the tests, elevated aerials operating on a much longer wavelength were used and, as Marconi had already observed in Italy, much greater distances were achieved by so doing. Thereafter, the parabolic reflectors were consigned to the scrap-heap, where they were to stay for over thirty years.



4 ***Scimitar H Manpack, in use, in tactical setting***

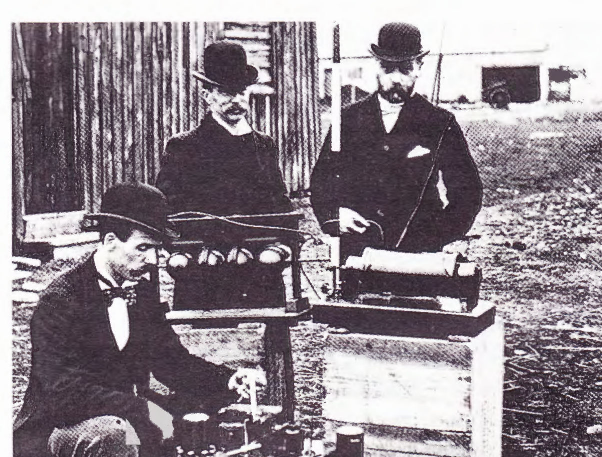
The tests on Salisbury Plain – and later across the Bristol Channel (fig. 5) – continued throughout the summer and autumn of 1896, and the range of communication increased to nine miles. Preece of the Post Office, Capt. Kennedy of the Royal Engineers, and representatives of the Royal Navy were very impressed with the possibilities of the technique that Marconi, just turned 22 years of age, had demonstrated to them. Further tests were therefore planned on a much more ambitious scale.

Preece, in particular, was by then sure that in his own experiments he had been investigating the wrong system in his attachment to the induction method of transmission. He magnanimously paid tribute to Marconi in a lecture he gave to the Royal Institution in 1897(4), saying:

'He (Marconi) has not discovered any new rays, his receiver is based on Branly's coherer...but he has produced a new electric eye, more delicate than any known instrument, and a new system of telegraphy that will reach places hitherto inaccessible....'

This tribute effectively staved off the scurrilous criticism of a disbelieving scientific world and a somewhat hostile press. Lord Kelvin, later to be a close friend of Marconi, was one of the early doubters. 'Wireless' he is said to have snorted 'is all very well, but I'd rather send a message by a boy on a pony'.

Throughout this period, Marconi maintained a quiet and dignified modesty when other young men of his age in similar circumstances might have been forgiven for becoming conceited. He is



5 ***Post Office engineers examining Marconi apparatus during tests made across the Bristol Channel in 1897***

very accurately described by H. J. W. Dam of the Strand Magazine after an interview in 1897, a description which was true for much of Marconi's life. Dam wrote:

'He is a tall, slender young man, who looks at least thirty and has a calm, serious manner and a grave precision of speech which further gives the idea of many more years than are his. He is completely modest, makes no claims whatever as a scientist, and simply says that he has observed certain facts and invented instruments to meet them.'

In the same interview Marconi told Dam:

'I do not wish to be recorded as saying that anything can actually be done beyond what I have already been able to do.'

There is little doubt that Dam must have remembered what he had written about Marconi when the world heard that Marconi claimed to have succeeded in receiving signals across the Atlantic Ocean, a claim that was doubted by many for some seventy years.

A lifelong characteristic of Marconi was his willingness to recognize the contribution made to the art of wireless by other workers in the field. A typical example can be found in his discourse delivered to the Royal Institution in 1900[5]. He opened by calling attention to those workers saying:

'When Ampère threw out the suggestion that the theory of universal space possessed of merely mechanical properties might supply the means for explaining electrical facts, which view was upheld by Joseph Henry and Faraday, the veil of mystery which had enveloped electricity began to lift. When, in 1864 Maxwell published his splendid dynamical theory of the electromagnetic field and devised the theory of space waves, and Hertz had proved experimentally the correctness of Maxwell's hypothesis, we obtained, if I may use the words of Professor J. A. Fleming, the greatest insight into the hidden mechanism of nature which has yet been made by the intellect of man.'

'We cannot pay too high a tribute to the genius of Heinrich Hertz who worked patiently and persistently in a new field of experimental physics, and made what has been called the greatest discovery in electrical science in the latter half of the nineteenth century. He not only brought about a great triumph in the field of theoretical physics but, by proving Maxwell's mathematical hypothesis, he accomplished a great triumph in the progress of our knowledge of physical agents and physical laws.'

'The experimental proof of Hertz, thirteen years ago, of the identity of light and electricity, and the knowledge of how to produce and how to detect these space waves, the existence of which had been so far unknown, made possible true wireless telegraphy.'

A great man paying tribute to other great men! This was the very young man who already walked in high places, the young man who did not claim to be a scientist, and who had not yet attained his 26th birthday. This was the young man who had pitted his brains and his faith against scientists and engineers two and three times his age and, without scientific help, had emerged head and shoulders above the best men the world could produce.

By 1897, Marconi was fully committed to what Lord Rayleigh had described as a 'lifetime' with his wireless. He was now in need of help, both financial and physical. A company was therefore formed, called 'The Wireless Telegraph and Signal Co. Ltd.' with none other than Henry Jameson Davis as Managing Director. Very soon, at father Giuseppe's urgent request, this Company was called 'Marconi's Wireless Telegraph Co. Ltd.'

The Mature Marconi

What kind of man did Marconi turn out to be in his later years? What was his standing amongst the men who worked closely with him, his friends and the great men of science? More interesting than all, possibly, what was his standing in the minds of the people of the world?

Most people when they first met Marconi were struck immediately by his immaculate appearance, and then became intrigued by his unsmiling and shy – almost aloof – demeanour, and his serious and precise manner of speaking – just as Dam described him in 1897.

Notwithstanding his Italian/Scotch/Irish ancestry, he gave the impression that he was a man who would remain unflappable and calm even under the greatest strain. He spoke and wrote the English and Italian languages fluently and, in consequence, he was in great demand as a lecturer, writer and after-dinner speaker.

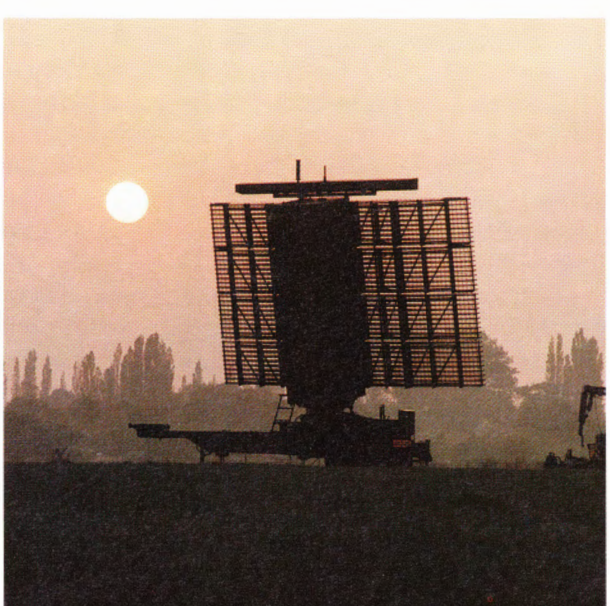
Marconi's assistants found him a good chief to work for, provided one quickly came to terms with the idea that one was expected to be on duty twenty-four hours a day, seven days a week. He certainly drove his assistants hard, but never so hard as he drove himself. He was always most polite to them and had the rather flattering habit of addressing them as Mr. So-and-So. They, for their part, always called him 'Sir', but amongst themselves they respectfully referred to him as 'G. M.'

There was the occasion when the writer had arranged to get married and with great temerity plucked up the courage to say on the Wednesday: 'Please Sir, may I go back to England to get married on Saturday?' 'Yes', replied Marconi, 'but be sure you are back by Monday'. He was back by Monday!

A most remarkable characteristic of Marconi was his ability to think big and persuade others to think big with him. Most of his outstanding experiments were carried out in later years on the most grandiose scale that probably, in this day and age, would not be considered economically prudent. But such was his fanatical obsession with 'his wireless', that he brushed aside such mundane considerations as cost-effectiveness as of little consequence. He had a remarkable gift of inventiveness and experimentation together with an intuitive insight into the causes of failure in a particular line of investigation, and what to do to remedy the defect. He had, in fact, what one might call 'wireless greenfingers.'

The fertility of Marconi's mind was a source of constant astonishment to those who worked with him. His imagination knew no bounds and he was able to forecast with uncanny accuracy the uses to which wireless, and wireless techniques, would one day be put – even up to two decades later.

This prophetic ability was, for example, well illustrated when he read his paper to the joint IEE/IERE in New York in 1922[6], where he described how radar would one day be made to work. In fact, radar was developed in 1935 (a sophisticated modern equivalent, the solid state Martello three-dimensional radar system, is shown in fig. 6). Again, in a paper he read in 1930 at Trento, Italy, he forecast the part that wireless would one day play in the fields of radio astronomy, radio meteorology and extra-terrestrial communication.



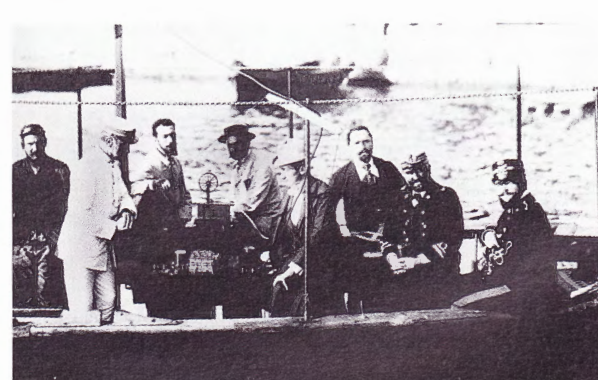
6 **The Martello three-dimensional air defence radar**

In connection with extra-terrestrial communication, Marconi was convinced that life of some kind must exist on some of the other planets in the universe and – perhaps – the 'inhabitants' might be trying to communicate with our Earth by the same kind of wireless waves that 'Earthmen' were using. On Marconi's instructions, a regular listening schedule was initiated in 1931. What kind of signal did he expect to hear? 'Listen for a regularly repeated signal' said Marconi. The tests, needless to say, gave a negative result – the receivers and ancillary apparatus at that time were far too insensitive. What a near miss though! Pulsars were subsequently observed by radio astronomers in 1967.

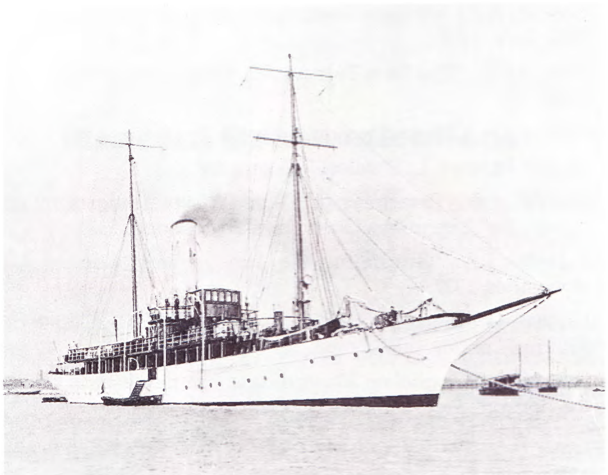
A few months before his death in 1937, Marconi forecast that television would one day be transmitted by wireless across the Atlantic Ocean – it was in fact achieved via the satellite 'Telstar' in 1962.

After his wireless, the sea was Marconi's great love, and most of his early work was expressly carried out with the aim of keeping ships at sea constantly in touch with each other, and with their shore bases (fig. 7).

In 1919 he acquired the 700 ton steam yacht 'Rovenska', built in Scotland for the Archduchess Maria Theresa of Austria. The S.Y. 'Rovenska' had been requisitioned by the British Admiralty to serve as a wartime minesweeper. Marconi re-christened the vessel S.Y. 'Elettra' (fig. 8 and also see the painting on the front cover); he gave the same name to his third daughter, who was born in 1930. Sadly, fate turned full circle, subsequently, when the S.Y. 'Elettra' was requisitioned by the Germans, again for duties as a minesweeper; she was sunk by Allied Air Forces in 1944 off Zara in the Adriatic.



7 **Marconi (4th from right) demonstrating wireless apparatus to Italian officials at Spezia in 1897**



8 *Marconi's steam yacht 'Elettra'*

9 *Marchese Guglielmo and Marchesa Cristina Marconi, 1933*

Without doubt, the happiest moments of Marconi's life were when he could bring together his love of the sea, his love of his wireless and the love of his family.

Not only was Marconi the pioneer and inventor of a wireless communication system, he was also a man of many other callings. He was as accomplished at the piano as he was at his wireless Morse key. The writer recalls the occasion when Marconi was operating his Morse key with his impeccable Morse characters and having to listen to a correspondent whose Morse was far from being impeccable; eventually his patience was exhausted and he asked his correspondent if that was the best Morse he could send. 'Yes', said the correspondent, 'it is the best I can do'. 'Well', replied Marconi, 'try using the other foot!'

He turned out to be a shrewd business-man, a skilful negotiator and a good administrator. He was a Parliamentarian, having been nominated to the Italian Senate when he was only 30 years old. As a statesman, he represented Italy at the signing of the Versailles Treaty after the first World War.

How did he stand with the men of science? There is no doubt that he was feared by those who had interests in the telegraph cables, particularly the submarine cables spanning the Atlantic Ocean. He was idolized by many and disliked by a few. Professor Sylvanus Thompson among the latter had this to say about him in 1902, following Marconi's successful bridging of the Atlantic:

'This young scientist's precocious reputation will be likely to end in a fizzle'.

Probably most important of all, how did the world in general receive Marconi? He numbered Kings, Queens and Heads of State amongst his friends. King George V conferred on him the Knight Grand Cross of the Royal Victorian Order in 1914. From all parts of the world, twenty-four other honours were bestowed on him. He acquired fifteen honorary Doctorates from world universities, although he himself had no academic qualifications in his own right.

He was appointed President of the Italian Royal Academy in 1930 and nominated President of the Italian National Council for Research; he was associated with thirty other scientific institutions.

Marconi received thirty-two major awards, including the Nobel Prize for Physics jointly with Professor Braun in 1909. Fifty major scientific papers on the subject of wireless exist in the name of Marconi, and 2 500 articles have been published by the lay and scientific press.

Such, then, was Marconi's standing in the world of science, and yet he himself was not a scientist – a fact which he seemed to take great delight in proclaiming.

This can certainly be said of Marconi – if an engineer can be defined as one who utilizes and controls the energies of Nature for the convenience and benefit of mankind, then Marconi was an 'engineer' worthy of the highest traditions.

As befitting such a man, the King of Italy marked his country's gratitude for the honour that Marconi had brought to Italy by conferring upon him the hereditary title of Marchese, in 1928 (fig.9).

In the evening of July 20th 1937, the day on which the great pioneer and inventor passed away, every wireless station in the world ceased to operate for two minutes. Could the world have paid a greater tribute to the man known as Marconi?

(Part II of this paper will appear in the next issue of the GEC REVIEW, Vol. 7, No. 2, and will cover some of the highlights of Marconi's career, including transmission across the Atlantic, the saving of 700 lives after the 'Titanic' disaster, and blind navigation using microwaves)

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